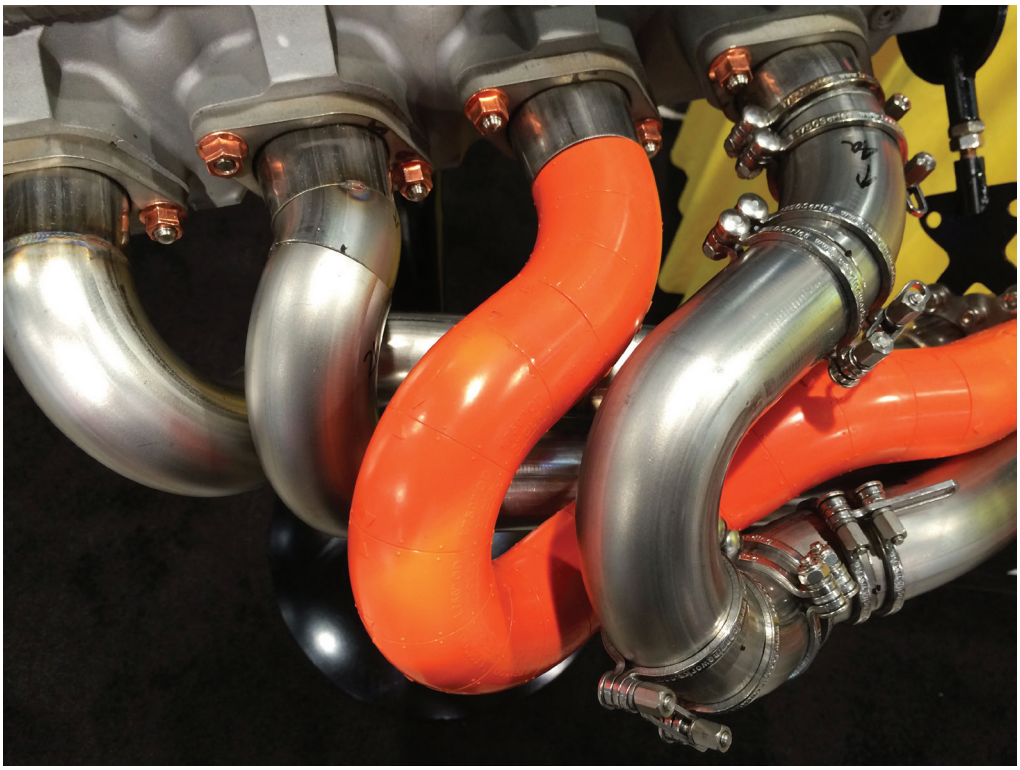
icengineworks®
precision exhaust design and fabrication

EHSeries Instructions Manual



Thank you for choosing the icengineworks® EHSeries exhaust header modeling systems to develop precise tubular exhaust header projects.

Despite their simple appearance and manual operation, the icengineworks® modeling blocks pack an enormous amount of design power not seen before. When used as suggested, they will quickly yield precise full-scale, 3D exhaust header models in real time, along with key design and fabrication information for the user to duplicate in metal.

With simple design features such as a constant overall length of 1.00 inch (arc or linear), or the same female/male connector among all OD sizes, the icengineworks® modeling blocks are a very flexible, easy-to-use, high precision design tool. Each block, molded in tough ABS plastic, is labeled with information such as its OD, its bend CLR (centerline radius) and witness lines for reference when building complex runners. For any given design, the user will be able to add, remove, replace and rotate the modeling blocks as many times as it takes until the design objectives are met. This innovative ability to quickly and manually revise, change and modify any design with precise and immediate feedback from the model constitutes the strength of this tool. It can be done over and over again until the entire design is completed to the user's satisfaction with minimum time invested, and no waste of expensive metal tubing or cutting and welding time.

With the plastic model completed, a metal version can be safely fabricated and its recipe recorded and preserved. It is our mission that the use of this product will result in a noticeable and immediate increase in productivity, quality of the emerging products and a drastic reduction in unnecessary waste of time and resources.

Before using, please read the following pages, which are meant as general guidelines and recommendations to get the most out of your investment. However, these are definitely not the final words. Experienced fabricators will be quick to adapt and incorporate their vast knowledge to this new design technology to reach higher levels of productivity and creativity.

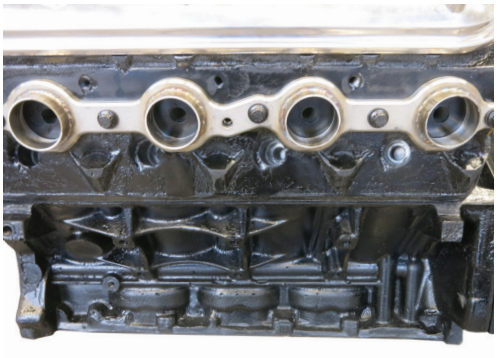
www.icengineworks.com

1. Contents

This box includes the following according to the part number as specified on the outside box label.

	Number of icengineworks Blocks per kit (BASIC/PRO)			
	1625EHSeries	1750EHSeries	1875EHSeries	2000EHSeries
Straight Block	30/60	30/60	30/60	30/60
2" – CLR Block	30/60	30/60	30/60	-
2.5" – CLR Block	-	-	30/60	-
3" – CLR Block	30/60	30/60	30/60	30/60
4" – CLR Block	30/60	30/60	30/60	30/60
5" – CLR Block	-	-	30/60	-
6" – CLR Block	-	30/60	-	30/60
Instructions Manual	1	1	1	1
Control Sheet Pad	1	1	1	1
Plastic Storage Case	1	1	1	1
Block Adapters	4/8	4/8	4/8	4/8

2. Getting Ready

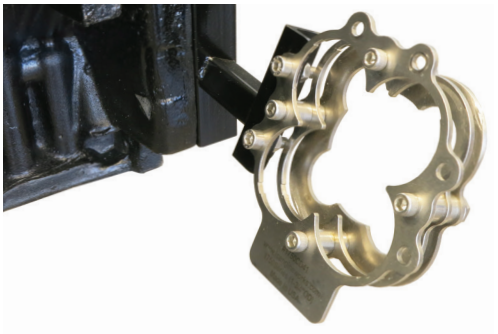


Plan ahead of time the key features in your intended design such as the OD and target lengths of the primary runners, based on experience or calculated. Decide if the runners will be equal-length, have steps, etc.; choose the type, number and location of the merge collectors.

The icengineworks® modeling block system is designed to work on engines with existing exhaust port flange (or flanges) with starter tubes that blend the exhaust port profile into round tubular diameters that match the block set.

We recommend the use of short starter tubes to make as much space available as possible when building complex icengineworks® modeling block strings. Make sure the exhaust flange and its starter tubes are secured to the cylinder head.

The icengineworks® modeling blocks main objective is to help you find the easiest pathway for each exhaust primary runner in the engine, from the starter tube at the cylinder head, to the merge collector.



Choose the location of the merge collector where the primary runners will meet. It is highly recommended that this component is already available at this time so that its location can be fixed. This will allow you to fully utilize the accuracy and precision of the icengineworks® modeling blocks when laying out the pathways.

Make sure that the merge collector(s) is firmly supported. The icengineworks® modeling blocks are designed to hold their weight only. They are not intended to support any metal component. Devise means to fix the location of the collector with minimum variation so that the precision of the design is not compromised.

3. Installing and Removing the icengineworks® Modeling Block Adapters

The icengineworks® plastic modeling blocks utilize simple anchoring devices (referred to as modeling block adapters) to attach them to the open ends of the starter tubes. This is how they work: when the bolt gets tightened on the small-OD end of the block adapter, the nut and the serrated washer lock against the large-OD metal washer and the assembly starts squeezing the rubber spacers. The large-OD end inside the starter tube makes the rubber grab and lock on the inner metal tube walls. On the small-OD end, the rubber squeezes past the female connector ID inside the icengineworks® modeling block trapping it in place without damage. Choose the type of icengineworks® modeling block, straight or curved, to start the assembly for each runner. All shapes work the same.

Insert the small-OD end of the block adapter through the female side of the icengineworks modeling block and tighten the bolt somewhat to get it to stay. Use the 5mm Allen wrench included.

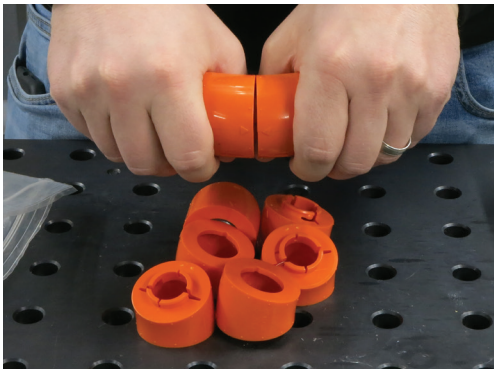
Next, insert the large-OD end into the starter tube while making sure that there are no gaps between the icengineworks® modeling block and the large-OD inner metal disk in the block adapter.

Begin tightening the bolt by holding with one hand the Allen wrench on the bolt, and holding with the other the block adapter/modeling block assembly flush against the starter tube. Some slippage may occur initially. Also, depending on the metal tube wall thickness, some pre-loading may be required on thin gage tubing. The plastic modeling block should sit flat against the edge of the starter tube. If the adapter cannot be pushed in enough, remove 1 rubber disk from the large-OD end as described in the adapter instruction manual included with the 5mm Allen wrench.

Once anchored, you can rotate the modeling blocks by holding them firmly and turning them to the desired position.

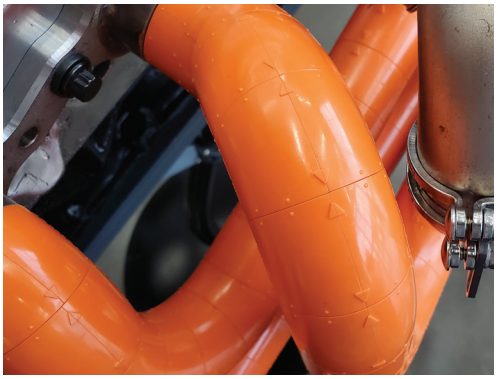
To remove, simply loosen the bolt and pull the modeling block/block adapter assembly away from the starter tube. Keep loosening the bolt until you can pull the block adapter from the modeling block.

4. Before starting an icengineworks® Modeling Block Assembly



The icengineworks® modeling blocks snap in and out easily. Therefore care must be observed when adding to or taking blocks away from a given assembly to avoid upsetting other blocks.

The modeling blocks rely on friction to maintain their position in addition to the ‘zero’ mark that ‘clicks’ the witness lines into alignment. To preserve their useful life, it is recommended to avoid excessive rotation between them, which may wear out their tight fit prematurely. To snap them in, hold firmly with one hand the receiving block, particularly if it is already part of a series of blocks, while pushing in the new block evenly with the other hand. Once they are snapped together, you can adjust the proper rotation gently. To break them apart, wrap your thumb and index fingers around each of the icengineworks® blocks to be separated, and hold your hands touching each other over the joint. Then, squeeze your hands tight. As they push away from each other, the blocks free up evenly and smoothly. Do not use sharp objects to pry the blocks open as this may damage them.

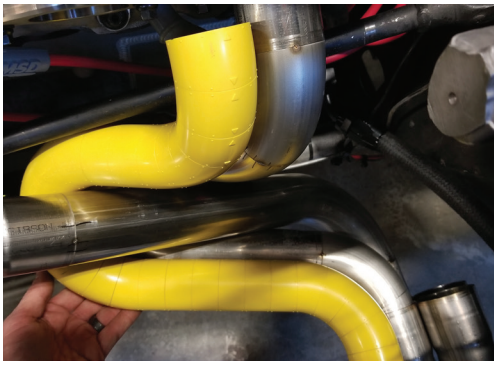


The icengineworks® modeling blocks have arrows molded at each end. When aligned, these markers indicate when those consecutive blocks can be sourced from the same J- or U-bend metal section during fabrication. Of course, this is true provided that they all have the same CLR.

When arrows do not line up, it means that at that location along the primary runner, a new section will need to be added (welded with a relative rotation). We refer to this as a weld joint.

With little practice, it will become evident how easy it is to design for the least amount of metal sections required when forming a given runner. This practice minimizes the cutting and welding by grouping consecutive blocks of constant-CLR with straight blocks. By keeping track of the number of weld joints, you are always aware of how many sections need to be cut and welded, and where those welds will be located in the design. If they are in a hard-to-reach area, you may want to redesign that part of the runner. This information is extremely valuable as the entire cost of the project (metal, cutting and welding labor) can be estimated even before cutting the metal.

5. Controlling your Design

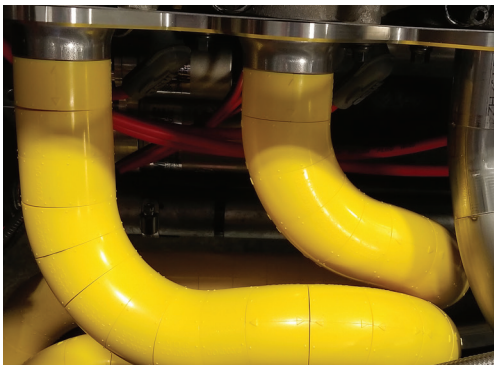


Based on the design you have in mind, it is easier to start it beginning with the cylinder that seems to pose the biggest challenge. By laying out the most difficult pathway first, the rest of the design will become progressively easier to figure out.

Try to create a picture in your mind of how the final design should look so that the initial choices of icengineworks® modeling blocks that go into the design approach the correct ones. By doing this, you will reduce the required corrections when available routing space becomes limited.

The icengineworks® modeling blocks are a high precision design tool that will yield better results when the blocks are not forced into shapes that they would not achieve freely. If the blocks cannot take naturally the desired shape, it is unlikely that the metal will. Read more on this in section 6.

6. Correcting and Optimizing

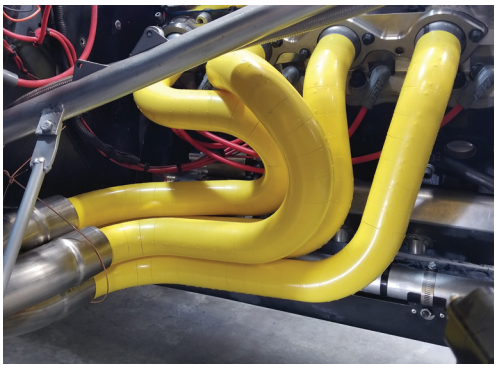


Any design process requires constant revisions and corrections until the desired goal is achieved. The icengineworks® modeling blocks are no exception to this rule, but the speed and simplicity at which this is achieved is one of its greatest strengths.

As your design grows with new elements being added or replaced, some adjustments and corrections will become necessary in order to continue. As you sort out unexpected situations, new opportunities will arise. And so, the more time you spend analyzing and working the design, the more insight you will have to complete it to your satisfaction.

Keep these simple tips in mind: build icengineworks® block strings of constant-CLR elements only between weld joints. Adding straight blocks before or after those constant-CLR sequences can sometimes reduce the number of metal sections and therefore the amount of cutting, deburring and weld time required.

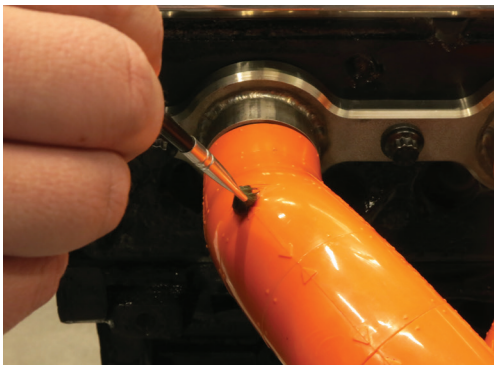
7. Finalizing your Design prior to its Fabrication



When you are satisfied with your exhaust header model and it feels right in every sense, take some additional time to carefully review each runner to make sure that there are no unwanted gaps or that the modeling blocks, specially those at the weld joints, have not moved or rotated unexpectedly. Misalignments or gaps will introduce errors and inaccuracies when the metal version is built. Make sure witness line alignments among blocks in constant-CLR curved sections remain 'zero-ed' in.

If your design calls for equal-length primary runners, verify the number of modeling blocks in each runner one last time.

Finally, make sure all the icengineworks® modeling block strings are floating freely and none is pushed or forced into their current position.



Depending on the scope and the marketability of the design created with the icengineworks® modeling systems, some organizations may choose to preserve it as full-scale, 3D permanent plastic reference, which can be further analyzed for costing, manufacturing or other purposes such as customer reviews or display.

If this is the case, the icengineworks® modeling blocks can be glued together at the joints using liquid plastic cement, available at hobby or crafts shops. Because of the capillary effect, only a drop or two of cement are required at the joint lines to weld them permanently.

Important note: Please keep in mind that this process cannot be reversed and it will not be possible to use those icengineworks® modeling blocks again in another design. For new design work, replacement icengineworks® modeling blocks will be required.

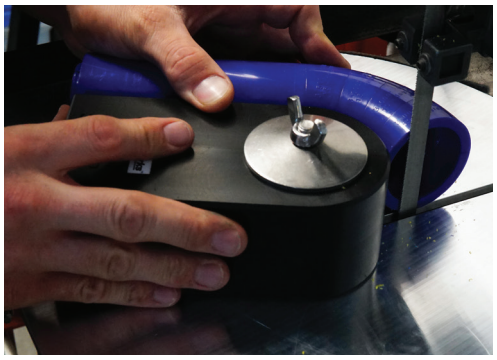
8. Transferring your Design to Metal

Create a list of the metal sections required for each primary runner. Fill out one of the U-Bend Metal Tubing Control Sheet included following the printed directions.

According to your design, black out with a pen or pencil, complete blocks in the diagram for each section in each runner. It is very important to properly label each section with cylinder information, its position along the runner and the flow direction to avoid confusion. Fill all available spaces, before starting out a new bend to keep to a minimum the required U-bends to buy.

The completed form becomes the recipe for the parts in your specific exhaust header design and is also an exact shopping list for the metal tubing you need. Add up the total number of filled U-Bends per CLR and choose the material and wall thickness to carry out the project. Even though the icengineworks® modeling block systems minimize waste in the fabrication of exhaust headers, it is still good practice to order one or two additional bends per CLR in case something does not go as planned. Have the metal tubing available before moving to the next step.

9. Fabricating the Metal Sections with the icengineworks® CUT system

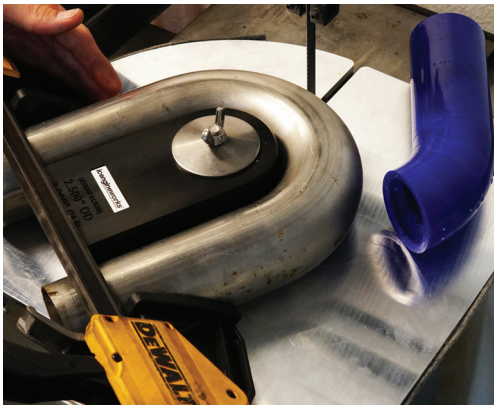


The icengineworks® tube-cutting spacers and the universal icengineworks® pivoting table (p/n PIV1000) will simplify the fabrication of your design. Use them to obtain consistent metal cuts that are always perpendicular to the bend's centerline. This is critical to achieve precise butt-to-butt joints that are easier to weld between the metal sections. These tools require the availability and access to a vertical band saw equipped with a rip fence and a minimum of 10" of throat as shown (a standard Wilton 14" Band Saw Model 8201 is used for this manual).

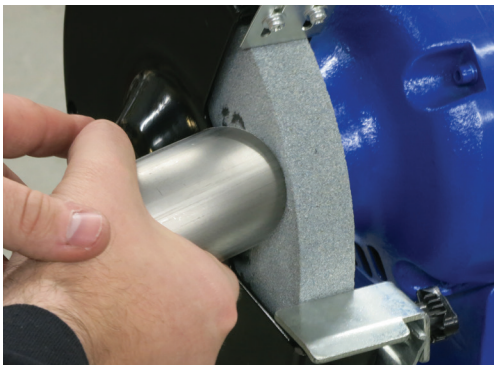
Depending on the saw you use, in most cases, the blade thickness needs to be taken into consideration when making the cuts to avoid getting slightly shorter metal sections. Care must be taken when setting the rip fence and establishing the blade path at one side of the middle path to the stud center.

Using a rubber-tipped carpenter c-clamp to secure the U-bend legs flat around the icengineworks® tube-cutting spacer is recommended to reduce vibration during the cutting operation. To achieve an exact cut, also make sure the U-bend lays completely flat against the base. The icengineworks® solid HDPE plastic icengineworks® tube-cutting spacers were designed to serve two purposes: first as precise guides that allow the easy transfer of your icengineworks® modeling block design, without having to know the cut angle, to the metal tubing to be cut by setting the spacer angle of rotation; and second, as solid support during the actual cutting of the marked metal tubing sections on a properly adjusted vertical band saw.

Following the Control Sheet filled out previously; use spare icengineworks® blocks to recreate the first section listed in your design. You need only a handful of blocks that you rearrange to form the required sections.



Start with the first section in your Control Sheet and create an equivalent block assembly. Place the plastic section around the matching-CLR icengineworks® cutting spacer and make sure there are no gaps between the spacer and the block section. Bringing the PIV plate forward towards the blade rotate both until the curved end of the blocks touches the blade. Tighten the wing nut to secure the angle cut to be made. Proceed to make the cut. Use the plastic section again to lay it on top of the metal section you just cut and mark off where the straight section needs to be trimmed off. We recommend using a horizontal band saw or a chop saw. Label such section to avoid mixing sections later. Move on to the next section in that runner and reassemble spare blocks into that new shape. Repeat until all the metal sections are clearly marked. It is time now to start the cutting of the metal tubing.



Clean up and deburr the cut sections with a wire wheel or similar. Verify that the metal sections cut are exact duplicates of the block-modeled sections. This can be achieved by placing the plastic block section over the metal version and making sure the ends are aligned vertically. The success of the icengineworks® modeling blocks depend on the user's ability to recreate metal cuts that are perpendicular to the centerlines of the bends as well as being a faithful metal reproduction of the plastic version. This is critical to preserve the model precision for a smooth transition between sections and also to guarantee a simplified welding process.

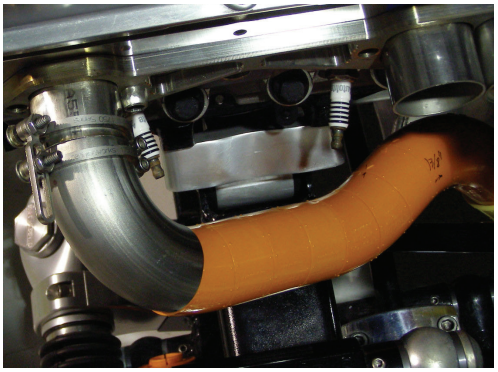
The resulting cut sections should have nice circular ends. In some cases, due to the extreme stresses the tubes go through during bending, they may loose their roundness at those sections. Their profile may have lost their roundness and may seem 'egged'. It is recommended in these instances that the tube roundness is restored as much as possible. By clamping its ends to a vise and gradually pressing on them, the circular profile can be recovered to a good extent. Ideally, a tube expander would be preferred. This simple action will facilitate the creation of authentic butt-to-butt joints with a reduced risk of burning the tubes when welding.

With the introduction of the new icengineworks® tack welding clamps, the actual fabrication of the exhaust header in metal has been now drastically simplified and can be completed in record time.

In the past, it was necessary to transfer witness lines from the blocks to the metal sections, and tack-weld them gradually section by section. This method was slow and not very accurate since an error in the 'clocking' of any of the tubing sections could be easily and inadvertently introduced even if the witness lines looked right. The more sections a given exhaust header runner had, the more difficult it became to get it right the first time. Each joint posed a potential problem of precision. In many cases, breaking tacks was a fairly common occurrence. Not anymore.

The new icengineworks® tack welding clamps offer the unprecedented ability for the user to temporarily assemble the entire runner through gapless joints for test-fit prior to tack welding them in place. Regardless of how many sections are to be welded, precise clocking and adjustments among all tube section joints can be quickly made until the entire runner fits its intended endpoints. Then, all runner joints can be safely tack welded at once.

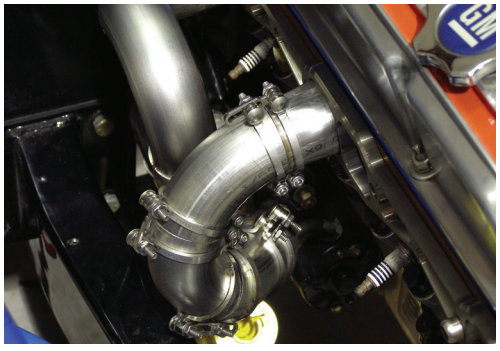
10. Exhaust Header Construction



Having all the metal parts cut and ready to be tack welded, the actual fabrication for each exhaust header runner can start at either end of it. Separate the cut sections for each runner according to the Control Sheet created for this specific project.

Starting with one runner, and based on the plastic blocks model, locate the first section, the second one, and so on. Identify their orientation (flow direction, etc.). Slip icengineworks® tack welding clamps over the tube ends to form joints among all the metal sections. You will need a 5/16" wrench or socket in a driver to tighten the nuts at the adjustable link only. The 3/8" nuts holding the pivoting hinge do not require tightening or adjustment during the actual use of the clamps.

The icengineworks® tack welding clamps require 2 basic adjustments and later, the fine tuning of them. The first adjustment is the radial location of the setting ring and its pivoting hinge around the first tube, which creates the swinging motion to match the bend direction of the second tube in the joint. The second adjustment is done by locking the swinging ring along the second tube when it is 'butted' against the first. The resulting gapless joint should be located evenly between the setting and adjustable rings.

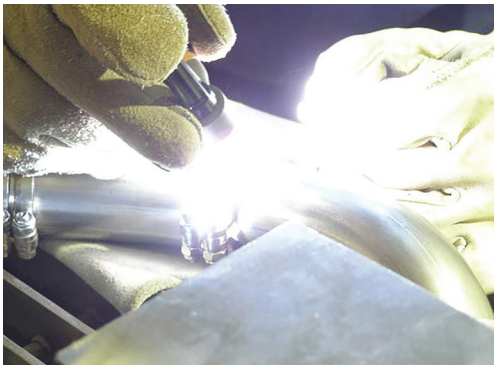


First, slide the setting ring of the icengineworks® clamp (the one with the fixed end on the adjustable link) about 1/8" from the end of the first tube to be joined (the first tube should be the one with the 'most straight' end of the two tubes to be joined). Spin the icengineworks® clamp until the swinging ring follows the curvature of the second tube end according to the design.

A quick glance at the model will reveal the approximate orientation (rotation relative to the first section).

Slide the end of the second metal section into the adjustable ring of the icengineworks® clamp to form the joint and bring the tubes together. Close the gap between them. A quick way to find the optimum location is to remember that the adjustable link will always run between the highest points of each of the tubes forming the joint.

Tighten the setting ring first and then the adjustable ring. Test for fit and adjust accordingly. Continue adding the third section to the open end of the second tube and so on. Repeat for the rest of the joints in the runner.

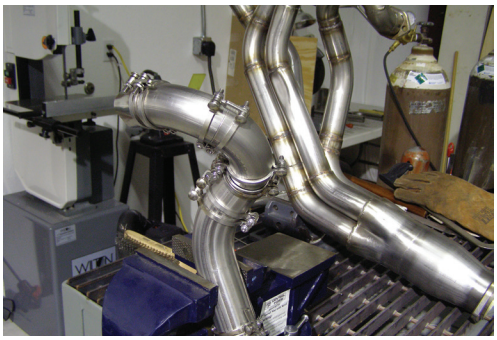


Regardless of how many joints are in the runner, once all tubing sections have been clamped together following the plastic model, proceed to fine tune each joint by test fitting the runner at the assembly jig or engine compartment.

Minute rotation adjustments are all is required to find the best fit. Slightly loosen the nuts clamping the adjustable link for each clamp to be readjusted, enough to allow the tube to rotate with some friction so that the original setting is not lost easily. Make gradual changes.

When the tubular assembly fits right, verify that all the icengineworks® tack welding clamps are tight so that the joints do not move. Make sure also that all the joints do not have any gaps in them.

Proceed then to place tack welds in at least 2 opposite locations around each joint. The icengineworks® tack welding clamps offer enough spacing between the rings at locations around the tubes, to comfortably access the joint with the TIG torch and tack the tubes together.



When all the joints have been tacked, loosen the nuts at the adjustable links icengineworks® tack welding clamps and carefully slide the clamps out of the runner.

If you are tacking the runner to the starter tubes at the head flange, slide the icengineworks® tack welding clamps out at the end of the runner before welding the collector in place.

In the event that the clamps end up 'trapped' in the runner because its ends have been welded, simply take them apart using a 5/16" and a 3/8" wrenches.

With the clamps removed, proceed to complete the welds around each joint.

11. Care after Use

With your exhaust header completed, take some time to keep your icengineworks® modeling blocks ready for the next project.

The icengineworks® modeling blocks are chemically bonded together using high performance glue. It may be possible that in certain rough work conditions, they may separate at their joint. In the event of this happening, simply glue the halves back together using liquid plastic cement recommended for ABS plastic, usually available at hobby or craft shops.

Wipe the blocks from any scribe made with the marker during the alignment process, or from oil or grease residues that may deteriorate the plastic over time. Household cleaners and a clean cloth are recommended.

Clean the icengineworks® block adapters from grease residue typically found inside the metal tubes. Some of the lubricants used may damage the rubber spacers as well The cardboard tube they came in is designed as a convenient place to store them.

Place your icengineworks® modeling blocks back in their heavy-duty bags and inside the plastic case. Store them in a safe place until next time.